M.S. Dissertation in Engineering

Contributions of Overseas R&D Subsidiaries on Headquarter Innovation Performance

: The Moderating Roles of Social Embeddedness and Knowledge Digestibility

August 2017

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이 논문을 공학석사학위 논문으로 제출함

2017 년 8 월

서울대학교 대학원

협동과정 기술경영경제정책 전공

정유라

정유라의 공학석사학위 논문을 인준함

2017 년 8 월

위 원 장 _____(인)

부위원장 _____(인)

위 원 _____(인)

Abstract

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Overseas R&D subsidiaries contribute to the cross-border knowledge sourcing of MNC headquarters by providing tacit and context-specific knowledge and reducing the search costs borne by the headquarters. This study examines how overseas R&D subsidiaries allow their headquarters to source local knowledge from the host country. The study also investigates the effect on overseas knowledge sourcing caused by the external embeddedness of an overseas R&D subsidiary in the local network of the host country upon the formation of and experience with alliances entered into with local entities. In addition, the degree of knowledge digestibility that each headquarters retains as a condition by which host country knowledge sourcing of headquarter can be effectively facilitated by the host

country R&D subsidiary is also investigated.

The study tests the hypotheses established using a data sample representative of the geographical distribution of overseas R&D subsidiaries of 100 multinationals which were included on the Fortune 500 MNC list in the year 2008 and the patent data of each firm. The study provides empirical evidence that the headquarters can benefit from the existence of a R&D subsidiary when it exists in a host country with abundant knowledge. Moreover, the findings suggest that the degree of overseas R&D subsidiary's embeddedness in the host country local network will reinforce the role of host country R&D subsidiary on host country knowledge acquisition and learning of the headquarters.

Keywords: Multinational Corporation, Overseas knowledge sourcing, Overseas R&D subsidiary, Innovation performance, Social Embeddedness, Knowledge Digestibility
Student Number: 2015-22879

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Chapter 1. Introduction

For the past few decades, there has been a steady trend of R&D offshoring (Song, Asakawa, & Chu, 2011). According to the literature, the fundamental reason why multinational corporations (MNCs) internationalize their R&D facilities is to acquire knowledge and learn from the host country (De Meyer, 1993; Dunning & Narula, 1995; Kuemmerle, 1999; Williams & Nones, 2009). However, the MNC strategic purpose of R&D internationalization has changed during the last few decades from an exploitation mandate to a home-base augmentation mandate (Cantwell & Mudambi, 2005; Kuemmerle, 1999). The role of an overseas R&D subsidiary was confined to leveraging home-based knowledge and adjusting products or processes to the local situation of the host country (Cantwell & Mudambi, 2005; Kuemmerle, 1999; Mudambi, Piscitello, & Rabbiosi, 2014). For the last few decades, the mandate of MNC R&D subsidiaries has changed to augmenting the parent firm's knowledge base with various knowledge resources from overseas R&D centers (Cantwell & Mudambi, 2005; Kuemmerle, 1999; Mudambi et al., 2014).

Prior studies suggest that a firm's capability to recombine knowledge is a fundamental driver of its innovation (Carnabuci & Operti, 2013; Galunic & Rodan, 1998; Grant, 1996b; Yayavaram & Ahuja, 2008). MNCs strive to enhance the innovation performance of their headquarters by extending the knowledge base via cross-border knowledge acquisitions (Almeida & Phene, 2004; Williams & Nones, 2009). Reverse knowledge transfers from a

R&D subsidiary toward the headquarters have received attention among the various components of MNC knowledge networks along with the rise of the home-base augmenting R&D subsidiary mandate (Kuemmerle, 1999; Mudambi et al., 2014). A reverse knowledge transfer in MNC is known to contribute to the gaining of a competitive advantage by the MNC by providing the MNC with a guideline on how to adjust their global strategies, products, and processes (Ambos, Ambos, & Schlegelmilch, 2006; Gupta & Govindarajan, 2000; Mudambi et al., 2014). Prior studies suggest various factors that affect the degree of a reverse knowledge transfer and posit the influences of the factors on reverse knowledge transfer processes. The technological capabilities of an overseas R&D subsidiary and the host country itself, the role or mandate of the R&D subsidiary that evolves over time, the cultural and organizational distance among the knowledge provider and the recipient units are all important factors (Ambos et al., 2006; Asakawa, 2001; Song et al., 2011).

In this paper, the central research objective is to investigate how R&D subsidiaries allow their headquarters to source the local knowledge of the host country, following the tradition of the home-base augmenting R&D subsidiary mandate (Ambos et al., 2006). In addition, important properties of the target and provider unit of reverse knowledge transfers are examined. Specifically, the external embeddedness of overseas R&D labs and the knowledge digestibility of the headquarters are investigated as to whether they enhance the role overseas R&D labs play during foreign knowledge acquisition by the headquarters and in the knowledge integration processes.

US patent data and a data sample of multinationals with their R&D distributions, patents and alliances are used in this study, and simple ordinary least squares regression is adopted

for the hypothesis testing. The result suggests that cross-border knowledge sourcing and learning by MNC headquarters can be facilitated with the aid of overseas R&D labs, leading to improved innovation performance. Other findings regarding the role-enhancing condition of an R&D subsidiary suggest that the degree of external embeddedness of an overseas R&D lab further facilitates foreign knowledge sourcing and subsequent innovation activities by the headquarters.

This study contributes to the literature on the MNC R&D subsidiary home-base augmenting mandate to benefit the headquarters by examining cross-border knowledge sourcing via host country R&D centers, finding empirically that this strategy is efficient with regard to the future knowledge acquisition and learning activities of the headquarters, thus generating greater innovations. The findings have managerial implications as well as those for policymakers. First, the study suggests to R&D managers of MNC headquarters the need to provide support to host country R&D labs so that the labs can effectively become embedded in the local knowledge network of the host country. Secondly, MNC home country policymakers are suggested to support the domestic firm's outward FDI institutionally when considering long-run improvements in the MNC innovation performance.

The remainder of thesis is structured as follows. Section 2 presents the literature review of the study and hypotheses are developed in Section 3. Section 4 describes the data and methods for the empirical analysis, with Section 5 then presenting the empirical results. In Section 6, discussions of the findings and of the contributions and implications are presented.

Chapter 2. Literature review

2.1 MNC R&D offshoring

A growing number of firms internationalize their R&D for the purposes of knowledge acquisition and learning (Kuemmerle, 1997; Mudambi et al., 2014; Williams & Nones, 2009). Early studies of MNC R&D offshoring focused on the role of foreign R&D subsidiaries to exploit the knowledge bases of the home country or headquarters to generate innovations (Kuemmerle, 1999). For instance, overseas R&D facilities considered it their role to adjust the products and related knowledge that were developed by the parent firm to the local market demand and situations in the host country with increasing levels of complexity (Cantwell & Mudambi, 2005; Kuemmerle, 1999; Mudambi et al., 2014). For the last few decades, however, researchers noted that MNCs began to promote R&D offshoring not merely for the original purpose of home-base knowledge exploitation but also to augment the knowledge base of the parent firm in the home country (Kuemmerle, 1999). While analyzing the causes and effects of MNC R&D internationalization, many previous studies focused on MNC subsidiary level of performance outcomes or on the level of host country local knowledge sourcing by the R&D subsidiary (Almeida & Phene, 2004; Phene & Almeida, 2008; Song et al., 2011).

2.2 Reverse Knowledge Transfer (RKT)

Along with studies that view MNC innovation activities in light of the home-base augmenting mandate, reverse knowledge transfers, referring to knowledge transfers from an overseas R&D lab to the headquarters, have received considerable amount of attention (Kuemmerle, 1999; Mudambi & Swift, 2014; Tallman & Chacar, 2011). Among the various components of MNC knowledge networks, MNCs can acquire foreign knowledge via reverse knowledge transfers from host-country R&D centers and MNC headquarters can benefit from the RKT (Ambos et al., 2006; Phene & Almeida, 2008).

Previous studies of MNCs suggest some antecedents of inter- or intra- organizational knowledge transfers, especially reverse knowledge transfers. The antecedents can be categorized according to whether they belong to the target or provider of the knowledge. The properties of the host-country R&D subsidiary, i.e., the knowledge provider unit, have a substantial effect on the knowledge transfer and the subsequent impact of the knowledge transfer. For instance, the technological capability that overseas R&D center retains, the strategic role of the subsidiary, whether it also serves as an implementer or a global innovator, how competitive the host country is, and the number of host-country expatriates stationed at the R&D subsidiary all influence the extent and the quality of reverse knowledge transfers (Ambos et al., 2006; Björkman, Barner-Rasmussen, & Li, 2004; Harzing & Noorderhaven, 2006; Song et al., 2011). However, the capability of the knowledge seeker is also important to ensure the generation of the subsequent performance when utilizing the transferred knowledge. That is, the headquarters should have a certain

degree of absorptive capacity effectively to identify and acquire the host country knowledge and to benefit from the transferred local knowledge (Ambos et al., 2006; Gupta & Govindarajan, 2000).

However, the relative properties between the knowledge units also play important roles in the reverse knowledge transfer mechanism. The organizational distance and the cultural distance, the internal and external embeddedness of the overseas subsidiary, and the headquarters-subsidiary control mechanism pertaining to the headquarters evaluation criteria for its subsidiaries are crucial factors that influence knowledge transfers (Björkman et al., 2004; Cantwell, 2009; Song et al., 2011; Van Wijk, Jansen, & Lyles, 2008).

In accordance with the increasing amounts of attention paid to reverse knowledge transfers in MNCs, previous studies examined the levels of reverse knowledge transfers or the benefits gained by the MNC headquarters from reverse knowledge transfers. However, prior empirical studies of the effects of the home-base augmenting mandate by MNC R&D subsidiaries or reverse knowledge transfers are mostly based on survey data when measuring the extent of knowledge that is reverse-transferred or the positive influences of reverse knowledge transfers on the headquarters (Ambos et al., 2006; Mudambi et al., 2014). The present study examines that when MNC headquarter aims to acquire knowledge from overseas countries, the overall processes and consequences of the foreign knowledge sourcing can be beneficial with the aid provided by host country R&D subsidiary via reverse knowledge transfers, based on patent data. The definition of a reverse knowledge transfer in this study is rather broad; that is, it includes transfers of both tacit and explicit aspects of the host country's knowledge (Polanyi, 1962).

While Song and Shin (2008) studied factors related to capability that impact the extent of host-country knowledge sourcing by a headquarters, the present study investigates the consequences or effects of sourcing knowledge from the host country of a MNC R&D subsidiary. The contribution that an overseas R&D subsidiary makes to the knowledge sourcing activities of the headquarters can be fundamentally attributed to the existence of the R&D subsidiary in the host country or to the active interactions between the subsidiary and the local environment of the host country (Almeida & Phene, 2004; Cantwell, 1989; Tallman & Chacar, 2011). However, the effects of knowledge spillover stemming from being located in the host country and the effects of actively exchanging knowledge with host country entities do exist but are difficult to separate. Thus, the present study proposes that the effects of knowledge spillover obtainable by an overseas subsidiary's location are further amplified with overseas R&D subsidiary embeddedness in the host country, both of which can contribute to host-country knowledge acquisitions through reverse knowledge transfers.

2.3 MNC–specific difficulties in inter- and intra-organizational knowledge transfer

Previous work has presented a number of factors that may hinder international communications. First, cultural differences may influence knowledge acquisition and the comprehension of transferred knowledge (Goodall & Roberts, 2003; Williams & Nones,

2009). The liability of foreignness is a common issue that arises from what is known as the cultural distance (Goodall & Roberts, 2003; Schmidt & Sofka, 2009; Williams & Nones, 2009). Secondly, differences among potential knowledge provider and recipient units in terms of economic, legal and political aspects also play a key role in impeding effective knowledge acquisition and transfers (Evans & Mavondo, 2002; Williams & Nones, 2009). In addition, language differences and geographical distances are factors that influence cross-border knowledge acquisitions (Armstrong & Cole, 2002; Welch, Welch, & Piekkari, 2005; Williams & Nones, 2009). In order to acquire and learn from overseas knowledge and apply it to generate innovations effectively, MNCs should overcome these difficulties of knowledge transfers.

Chapter 3. Hypotheses

3.1 HQ's cross-border knowledge sourcing through a R&D subsidiary and its impact on innovations

One stream in previous research argues that firm innovations arise from recombination of existing knowledge with knowledge acquired from various sources (Galunic & Rodan, 1998; Grant, 1996b). Therefore, in order for headquarters of MNCs to gain a competitive advantage through innovation activities, they must endeavor to overcome the difficulties

regarding cross-border knowledge transfers (Ambos et al., 2006; Tallman & Chacar, 2011; Zucker, Darby, & Armstrong, 1998). In our current era of information, MNC headquarters attempt to acquire foreign knowledge, and the headquarters can directly search for the proper sources in host countries. However, when the MNC has a R&D subsidiary in a country from which the headquarters view as a source of knowledge, the overseas subsidiary can serve as a facilitator of the knowledge searching and acquisition processes by the headquarters.

The headquarters can also benefit from the accumulated efforts of the overseas R&D lab to close distances which may hinder the understanding of knowledge from the host country (Williams & Nones, 2009). Overseas R&D labs usually make efforts to alleviate the problem of the liability of foreignness and to build trust in host country environments, and such endeavors can reduce the psychic distances between the subsidiary and local entities of the host country (Evans & Mavondo, 2002; Williams & Nones, 2009). Moreover, the subsidiary may strive to narrow language differences considerably, beyond the level of merely being capable of translating (Welch et al., 2005; Williams & Nones, 2009). In addition, being located in a geographically convenient location may alleviate problems which can arise from long physical distances (Armstrong & Cole, 2002; Williams & Nones, 2009). These typical efforts of a host country R&D subsidiary to alleviate distances from host country local entities can have a positive impact on the host country's grasp of the subsidiary, from which headquarters can eventually gain advantages.

Having a R&D subsidiary in a country from which the headquarters wants to source knowledge can benefit the headquarters in its knowledge acquisition efforts in the host

country and can have positive effects on knowledge integration and thus, on subsequent innovative activities of headquarters. First, endeavors of the R&D subsidiary and a high level of understanding of local knowledge can contribute to enhancing the efficiency in the process of host country knowledge searching and acquisition by the headquarters. The foreign knowledge search process is uncertain and costly but can be guided by a R&D center's previous search activities (Dosi, 1988; Nelson & Winter, 1982; Phelps, 2010). Therefore, by referring to previously routinized feedback from the host country's search efforts, the headquarters can reduce the time and cost required to search for valuable local knowledge in the host country (Dosi, 1988; Nelson, 1982; Nelson & Winter, 1982; Phelps, 2010). Moreover, by virtue of host country overseas R&D subsidiary's typical efforts to alleviate cultural, language, and business differences, the quality of the knowledge of the host country sought by the headquarters would be improved with the aid of the subsidiary given its understanding of context-specific, localized and tacit knowledge of the host country (Ambos et al., 2006; Dhanaraj, Lyles, Steensma, & Tihanyi, 2004; Gertler, 2003; Oğuz & Elif Şengün, 2011; Williams & Nones, 2009).

Extended headquarter knowledge pools with efficient knowledge acquisition processes give headquarters opportunities to attempt other alternative knowledge recombination sets and to search further (Dosi, 1988; Hewett & Bearden, 2001; Nelson, 1982; Song et al., 2011). In addition, a more precise understanding of foreign knowledge with the aid of a host country subsidiary will enable R&D procedures with better combinations of knowledge and can reduce the unnecessary costs that can arise from misunderstandings of acquired knowledge, which can in turn contribute to enhance the efficiency of R&D

activities (Ambos et al., 2006; Dhanaraj et al., 2004; Nelson, 1982; Oğuz & Elif Şengün, 2011). With an extended knowledge pool and improved efficiency of knowledge recombination activities, opportunities to find optimal recombination of knowledge will also increase, leading to improvements in the performance of headquarter innovations (Dosi, 1988; Phelps, 2010).

Hypothesis 1: Cross-border knowledge acquisitions of a MNC HQ that are facilitated by the host country R&D subsidiary have a positive linear relationship with the subsequent innovative performance of the HQ.

3.2 External embeddedness of the overseas R&D subsidiary

Prior studies that take a social capital view of MNCs and foreign R&D strategies place emphasis on social relations during the learning and innovation activities of the MNC owing to knowledge embeddedness (Granovetter, 1985; Song et al., 2011). Uzzi (1996) provides a sophisticated definition of the concept of embeddedness, and among the categories of embeddedness, the present study focuses on structural embeddedness, especially the external embeddedness of a subsidiary in the host country local network (Song et al., 2011).

An overseas R&D center can benefit from having a degree of external embeddedness

as the R&D center promotes trust building in the host country or when it attempts to improve the accuracy of knowledge transfers (Uzzi, 1996). As overseas R&D centers come to form partnerships with local firms in a host country and thus gain a degree of embeddedness, the subsidiary's efforts to build trust in local communities can become more effective and can even promote subsequent partnerships (Zukin & DiMaggio, 1990). With a high level of trust building by an overseas R&D subsidiary, host country entities are less likely to behave opportunistically, which may also be beneficial to knowledge sourcing (Helper, 1990; Larson, 1992). Thus the embeddedness of a R&D subsidiary in a host country network can result in more sophisticated, high-quality understanding of local knowledge by the R&D subsidiary (Ambos et al., 2006; Tallman & Chacar, 2011). In addition, the quality of the knowledge of a host country that is reverse-transferred to the headquarters also increases (Zukin & DiMaggio, 1990).

In the virtue of the improved quality of the knowledge of the host country, the headquarters can save time and reduce the cost of searching for alternative knowledge otherwise necessary without such a fine-grained understanding of the host country's local knowledge (Nelson & Winter, 1982; Phelps, 2010; Zukin & DiMaggio, 1990). In addition, as the host country R&D center forms partnerships with local firms, the efficiency of knowledge integration procedures is likely to be enhanced because such partnerships or relational contracts can shorten the time required for knowledge acquisition and integration activities (Galunic & Rodan, 1998; Grant, 1996a; Nelson, 1982). Furthermore, as Uzzi (1996) argues, by gaining the experience of joint problem-solving through relational contracts, both the knowledge seeker and provider are more likely to exchange feedback

reciprocally in the face of problematic situations. Improvements in the speed and clarity of reciprocal feedback would contribute to the accuracy of the knowledge learning process in both short and long run (Hirschman, 1970; Uzzi, 1996).

To summarize, headquarters can gain a more accurate and speedy understanding of the local knowledge when the R&D subsidiary has a degree of embeddedness, as the entities holding local knowledge are less likely to behave opportunistically and both the R&D subsidiary and host country firm tend to participate in feedback exchanges after forming a partnership. In other words, the time and costs otherwise unavoidable due to misunderstandings can be mitigated such that the headquarters can attempt to gain a wider variety of alternative sets of knowledge recombination. With increased efficiency of knowledge searches and integration and recombination activities with a precise understanding of the host country's knowledge due to the embeddedness of the subsidiary, the headquarters will likely find optimal recombination sets of extended knowledge, which can lead to further improvements in the subsequent innovative performance of the headquarters.

Hypothesis 2: The external embeddedness of an overseas R&D subsidiary positively moderates the relationship between the cross-border knowledge acquisition of the HQ with the aid of an overseas R&D subsidiary and subsequent HQ innovations.

3.3 HQ’s knowledge digestibility

When seeing cross-border knowledge sourcing of the headquarters with the aid of a host country R&D center as a dyadic knowledge transfer, the knowledge digestibility of the headquarters as a knowledge recipient may be one of the critical factors influencing foreign knowledge acquisition.

Previous studies of knowledge digestibility emphasize size differences in the knowledge bases between the knowledge provider and the seeker, as these differences can affect knowledge integration procedures (Hennart, 1988; Kang, Jo, & Kang, 2015). If the size of the knowledge base of the provider exceeds that of the knowledge seeker, the subsequent knowledge integration processes can fall victim to increased complexity, which may reduce the willingness to source the knowledge (Carayannopoulos & Auster, 2010; Cloodt, Hagedoorn, & Van Kranenburg, 2006; Paruchuri, Nerkar, & Hambrick, 2006). Because firm innovations derive from knowledge recombination activities, excessive complexity during knowledge integration procedures would be detrimental to the efficiency of R&D activities and thus to the innovation performance of the headquarters (Dosi, 1988; Phelps, 2010).

However, with a sufficient level of knowledge digestibility that the headquarters retain, the problem of complex knowledge integration procedures can be alleviated (Hennart, 1988; Jo, Park, & Kang, 2016). In addition, an enhancement in knowledge digestibility implies an increase in the absorptive capacity of the headquarters. Therefore, the knowledge digestibility of the headquarters relative to the host country R&D subsidiary would further improve the efficiency of host country knowledge recombination by virtue of the alleviated level of complexity during the overall knowledge integration process and the enhanced

capability of the knowledge target. That is, along with the effects of efficiency improvements during the knowledge integration processes by virtue of reverse-transferred knowledge from the overseas R&D subsidiary, the efficiency can be further enhanced if the headquarters retains a certain degree of knowledge digestibility relative to the host country R&D center (Jo et al., 2016). Therefore, the headquarters may have an opportunity to attempt more diverse sets of knowledge recombination, making it more likely to move closer to the optimal knowledge recombination (Nelson, 1982). Considering that knowledge recombination constitute a key driver of firm innovations, headquarters that retain knowledge digestibility relative to the overseas R&D subsidiary can enjoy improvements in their innovation performance (Almeida & Phene, 2004; Williams & Nones, 2009).

Hypothesis 3: The greater the knowledge digestibility of the HQ, the greater the positive moderation effects of knowledge digestibility on the relationship between the cross-border knowledge acquisition of the HQ with the aid of an overseas R&D subsidiary and subsequent HQ innovations.

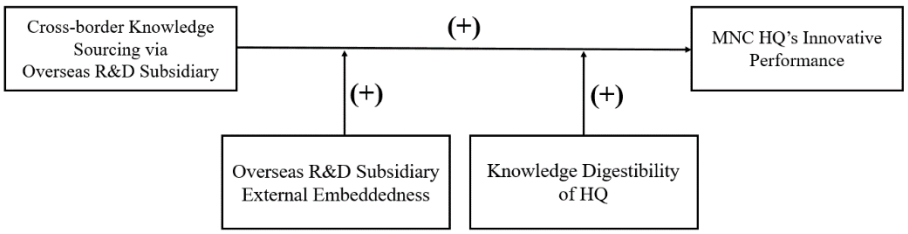

Figure 1. Research Model

Chapter 4. Data and Method

4.1 Data specification

This study uses data from UK Data Archive Study on the geographical distribution of overseas R&D labs of Fortune 500 multinationals (excluding financial services firms) with the observations made in 2008 (Prabhu, 2011). The UK Data Archive Study provides a dataset of each MNC's locations across 21 countries which are known as R&D leading sites (Prabhu, 2011). Financial data and other corporate information were obtained from Compustat and Datastream database. The sample of current study is based on the information on patents granted to each multinational in 2011, sourced from US Patent and Trademark Office (USPTO) database. According to Albert, Avery, Narin, and McAllister (1991), not only US firms but also foreign firms tend to apply for US patents for appropriability issues. Furthermore, an evidence from previous research suggests US patent as proper proxy for foreign firm's innovative performance (Dosi, Pavitt, & Soete, 1990; Jo et al., 2016). Firm alliance data was obtained from SDC Platinum database.

Among 500 multinationals, firms in less R&D intensive industry sectors excluded, through which process, 384 observations remain (Sterlacchini, 1999). After accounting for observations with missing data, 314 firms and their information are available. In addition, since the present study investigates the firm that has granted patents in year 2011, only 184 observations are left. After excluding firms without patents granted to headquarter in 2011,

164 firms are available. Furthermore, firms that does not have home country R&D subsidiary and observations with missing data in corporate financial information are ruled out. The final sample includes 100 observations. Table 1 provides the descriptive data of 100 multinationals with the number of host countries and overseas R&D subsidiary of each firm.

Table 1. Description of data on host country and R&D subsidiary

Number of firms		100
Number of host countries	*Average*	3.57
	Min	1
	Max	16
Number of overseas R&D subsidiaries	*Average*	3.22
	Min	0
	Max	22

4.2 Variable

4.2.1 Dependent variable

The dependent variable *MNC Headquarters Innovative Performance* can be measured in various ways. One of previous literatures captures innovative performance with the number of patents that each focal firm applied for during the period of observation, focusing on the scale of focal firm innovation performance (Phene & Almeida, 2008). Other stream of papers point out that scale aspects of innovative performance cannot reflect

the possibility of differences in importance among patents (Lanjouw, Pakes, & Putnam, 1998; Marhold, Kim, & Kang, 2016). Previous studies tried to capture the varying importance of each patent via patent citation, because the citation demonstrates how important each innovation is with its correlation with economic value (Phene & Almeida, 2008; Trajtenberg, 1990). The present study captures firm innovative performance by means of the linear weighted patent count with the equation shown below (Trajtenberg, 1990). The term WPC_j denotes the weighted patent count of each focal firm, while n_j is the total number of patents that are granted to each focal firm j during the period of observation. Finally, the term that indicates the total number of forward citations that each patent i subsequently received is denoted by C_i (Marhold et al., 2016; Trajtenberg, 1990).

$$WPC_j = \sum_{i=1}^{n_j} (1 + C_i)$$

Focal patents refer to the granted patents of each focal firm in the year 2011, and the number of citations subsequently received by each patent, or the forward citations of each patent is counted in the period of 2012-2015, because the patent citations tend to reach the highest point within three years (Marhold et al., 2016; Mehta, Rysman, & Simcoe, 2010). Finally, the variable *MNC Headquarters Innovative Performance* was calculated with a transformation to a log scale of weighted patent count.

4.2.2 Independent variable

Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary

As the present study investigates the role of foreign R&D subsidiaries in facilitating cross-border knowledge sourcing and learning by the headquarters, backward citations of the headquarters were utilized in the calculations of the variable, termed here as *Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary*. The calculation of this variable was based on backward citations, referring to patents cited by each granted patent of a focal firm (Lee, Park, & Kang; No & Park, 2010; Trajtenberg, Henderson, & Jaffe, 1997). Given that the present study focuses on the situation in which the MNC headquarters attempts to source foreign knowledge and learn from the sourced knowledge, the focal backward citations were narrowed down to foreign backward citations, of which the country of origin is different from the home country of the MNC. As knowledge integration or application takes time, the time lag between knowledge acquisition and subsequent innovation activities must be considered (Phene & Almeida, 2008). Here, a two-year time lag is adopted because innovative performance is analyzed based on patent grants, not applications. Unlike previous studies which examined innovation performance through patent applications by adopting a one-year lag in the patent portfolio of the MNC, the present study adopts a two-year lag because most patents tend to be granted within two years after the application (Mehta et al., 2010; Phene & Almeida, 2008). Foreign patents that lagged patent portfolio in the year 2009 cited are investigated for five-year periods; that is, backward citations from 2004 to 2008 are examined. The intent of the current study is to examine whether a headquarters can benefit from a host country R&D center in acquiring and integrating host country knowledge. Following earlier work which measured the level of host country knowledge sourcing via the number of citations from the host

country, the independent variable *Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary* is measured by counting foreign patents cited by the MNC headquarters from countries where they have established a R&D subsidiary (Song & Shin, 2008).

Overseas R&D Center External Embeddedness

The degree of embeddedness of the subsidiary is measured in several different ways in the literature. Song et al. (2011), for instance, adopted a composite index based on a survey questionnaire that includes questions on research contracts with local research institutions and joint appointments with local universities (Song & Kang, 2005). In a similar vein, by extending the conceptualization of R&D collaborations between a MNC subsidiary and the headquarters according to Frost and Zhou (2005), overseas subsidiary R&D collaborations with local entities can be adopted as a measure of the external embeddedness of a subsidiary. In the present study, the variable *Overseas R&D Center External Embeddedness* is operationalized as the total number of alliances between the MNC and local firms in the host country from 2004 to 2008. Despite the fact that both alliances and M&A activities are known to be crucial for a firm to gain access to external knowledge, M&A activities are not included here because M&A can be another entry mode of MNC foreign direct investment just like greenfield investments (Ahuja & Katila, 2001; Almeida & Phene, 2004; Desyllas & Hughes, 2008). Alliances indicate reciprocal exchanges and the joint development of technology among partners, from which the MNC headquarters or its R&D

subsidiary gains an opportunity to access local knowledge through the alliance (Almeida & Phene, 2004; Gulati & Singh, 1998). Because previous five-year alliance experiences would affect firm innovative activities in year t, the duration of the alliance count is from 2004 to 2008 (t-5 to t-1) in the present study (Almeida & Phene, 2004).

MNC Headquarters Knowledge Digestibility

According to Jo et al. (2016), knowledge digestibility can be constructed based on a measure that reflects the relative sizes of the knowledge bases of the knowledge source and the seeker (Ahuja & Katila, 2001). Processes and routines when handling knowledge differ across organizations or units, especially when organizations are located in different countries (Williams & Nones, 2009). Therefore, the number ratio of the knowledge provider and target can serve as a proxy for knowledge digestibility by reflecting the complexities associated with transferring knowledge and the knowledge recipient's capability to understand the transferred knowledge. In the present study, the proxy for the *MNC Headquarters Knowledge Digestibility* is measured as follows.

$$\boldsymbol{MNC\ Headquarters\ Knowledge\ Digestibility} = \frac{\boldsymbol{The\ number\ of\ overseas\ R\&D\ subsidiary\ of\ each\ MNC\ (in\ t-3)}}{\boldsymbol{The\ number\ of\ home\ country\ R\&D\ subsidiary\ of\ each\ MNC\ (in\ t-3)}}$$

The time lag between the observation time of the geographical distributions of R&D subsidiaries and the time focal patents were granted to each multinational is three years. Because the R&D center distributions were observed in 2008, focal R&D subsidiaries may effectively take an active role in facilitating the host country knowledge acquisitions of the headquarters during the period of 2009-2010.

4.2.3 Control variable

In the present study, several control variables that may affect the innovative performance of the MNC headquarters are employed. *R&D Intensity* is included in order to rule out the effect of R&D intensity on the ability of a firm to innovate (Phene & Almeida, 2008). The variable is operationalized as firm R&D expenses divided by firm sales in 2008. *Firm Size* is included to control its potential impact on the innovative performance of the firm. *Firm Size* is defined as the log-transformed total assets of a firm in 2008. The variable *Technological Capability* is included due to the potential effects of the innovative capability of each MNC on its subsequent innovative performance. *Technological Capability* is defined as the number of patents granted to each multinational for five years, from 2004 to 2008 inclusive (Almeida & Phene, 2004; Song et al., 2011). The operationalization of *Technological Capability* is based on previous studies which measured innovative capability according to the knowledge stock of the firm or organization (Almeida & Phene, 2004). *Firm Total Foreign Citation* is also included to control the effects of foreign knowledge sourcing by the MNC from countries where they do not own an R&D subsidiary

on the innovative performance of the MNC headquarters. The variable *Firm Total Foreign Citation* is measured as the total number of patents originating from overseas countries and were cited by the MNC headquarters from 2004 to 2008 inclusive. *Firm Total Backward Citation* is included because when a firm cites more patents regardless of the country of origin of the cited patent, it becomes more likely that firm innovation performance levels will be enhanced (Song et al., 2011). *Firm Total Backward Citation* is calculated as the total number of backward citations of patents granted for each firm in 2011. The variable *Previous Alliance Experience* is employed to rule out the effect of previous alliance experience during the period of 2000-2003 on the innovative activities of a firm in 2009. Some prior researchers stress the importance of alliance experiences during the years between t-5 and t-1 on firm innovation in year t (Almeida & Phene, 2004). *Previous Alliance Experience* in the present study is defined as the number of firm alliances entered into by each firm from nine to six years prior to the innovation activities to rule out the potential effects of alliance experiences during that period. Dummy variables *Firm Industry* and *Headquarters Home Country* are also employed. The variable *Headquarters Home Country* serves to distinguish the nationality of the firm, i.e., whether the firm is from the US or not. The USPTO database is utilized in this study of multinational corporations because US patents are considered to be a proper indicator of firm global inventive activities and performance capabilities (Simonetti, Archambault, Côté, & Kale, 2007). However, MNCs from US may have a propensity to apply for US patents more than non-US multinationals, which can lead to differences in the innovative performance between the two groups. Thus, *Headquarters Home Country* is included as a control variable.

4.3 Method

Considering that the dependent variable *MNC headquarter innovative performance* in the present study is the log-transformed weighted patent count that has continuous values, simple ordinary least squares regression is one of the methodology that can be adopted for testing hypotheses. However, there can be a potential heteroscedasticity problem because the present study is based on a cross-sectional data. Thus, an additional test for heteroscedasticity is conducted and the result of the white test indicates a homoscedasticity. Therefore, the use of ordinary least squares regression as a methodology can be justified.

Chapter 5. Results

<Table 2> shows the descriptive statistics and pairwise correlation of each variable. The level of correlations between the independent variable are considerably high, which can imply the multicollinearity issue. Therefore, a variance inflation factors (VIF) were calculated to check whether multicollinearity problems exist in testing model of present study. <Table 3> shows the mean value of VIF. Previous studies proposed threshold value of VIF as 10 and if VIF of model exceeds the level, there can be multicollinearity problems

Table 2. Descriptive Statistics

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1. MNC Headquarters Innovative Performance	6.73	0.42	1.00									
2. Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary	3.56	0.30	0.79	1.00								
3. Overseas R&D Center External Embeddedness	5.94	0.68	0.40	0.43	1.00							
4. MNC Headquarters Knowledge Digestibility	1.40	0.18	0.27	0.26	0.33	1.00						
5. R&D Intensity	4.45	1.22	0.04	0.01	0.09	0.02	1.00					
6. Firm Size	137.04	22.38	-0.10	-0.17	-0.10	0.24	-0.07	1.00				
7. Technological Capability	1272.78	272.66	0.64	0.55	0.49	0.31	0.07	0.01	1.00			
8. Firm Total Foreign Citation	2914.09	795.67	0.59	0.59	0.34	0.31	0.02	-0.04	0.85	1.00		
9. Firm Total Backward Citation	5021.52	945.07	0.75	0.63	0.33	0.31	0.04	-0.04	0.85	0.87	1.00	
10. Previous Alliance Experience	19.56	2.56	0.52	0.49	0.75	0.47	0.11	-0.04	0.73	0.54	0.52	1.00

Table 3. Ordinary least squares regression results table

	Model 1	Model 2	Model 3	Model 4	Model 5
Control variable					
R&D Intensity	-0.0059 (0.0227)	-0.0143 (0.0166)	-0.0157 (0.0164)	-0.0145 (0.0167)	-0.0157 (0.0166)
Firm Size	-0.0004 (0.0013)	0.0000 (0.0009)	-0.0003 (0.0009)	0.0003 (0.0011)	-0.0003 (0.0011)
Technological Capability	-0.0002 (0.0003)	0.0000 (0.0002)	-0.0001 (0.0002)	0.0000 (0.002)	-0.0001 (0.0002)
Firm Total Foreign Citation	-0.0002* (0.0001)	-0.0002* (0.0001)	-0.0002*** (0.0001)	-0. 0002** (0.0001)	-0.0002*** (0.0001)
Firm Total Backward Citation	0.0005*** (0.0001)	0.0003*** (0.0001)	0.0003*** (0.0001)	0.0002*** (0.0001)	0.0003*** (0.0000)
Previous Alliance Experience	0.0445 (0.0165)	0.0136 (0.0125)	0.0208 (0.0155)	0.0141 (0.0145)	0.0204 (0.01723)
HQ home country (Dummy) Industry (Dummy)			*Included* *Included*		
_Cons	3.9505*** (0.7799)	0.7794 (0.6707)	1.0208 (0.6752)	0.7378 (0.6796)	1.0290 (0.6934)
Independent variable					
Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary		0.9598*** (0.1074)	0.8968*** (0.1163)	0.9418*** (0.1116)	0.8975*** (0.1185)
Overseas R&D Center External Embeddedness			-0.1275* (0.0692)		-0.1294* (0.0741)
Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary X Overseas R&D Center External Embeddedness			0.0208* (0.0109)		0.0211* (0.0120)

Table3. Continued

	Model 1	Model 2	Model 3	Model 4	Model 5
MNC Headquarters Knowledge Digestibility				-0.1367 (0.2167)	0.0202 (0.2318)
Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary X MNC Headquarters Knowledge Digestibility				0.0351 (0.0554)	-0.0031 (0.0588)
Observations	100	100	100	100	100
R-squared	0.6393	0.8100	0.8182	0.8109	0.8183
Adj R-squared	0.6032	0.7886	0.7932	0.7849	0.7883
Mean VIF	7.56	7.66	4.17	4.05	4.90
Max VIF	3.19	3.35	7.81	8.51	8.66

*** p<0.01; ** p<0.05; * p<0.1

(Hair, Anderson, Tatham, & Black, 1995; Kang & Kang, 2014). The maximum VIF for each model in the present study is lower than 10, thus the data in the present study does not have multicollinearity problems.

The results of the OLS regression analyses are represented in <Table 3>. The effects of each independent variable and control variable on the dependent variable *MNC Headquarters Innovative Performance* could be examined throughout the models. In Model 1, among various control variables, the effects of *Firm Total Backward Citation* and *Firm Total Foreign Citation* on the dependent variable turn out to be significant. In Model 2 *Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary* has a positive and significant direct effect (p<0.01) on headquarter subsequent innovative performance. The direction and significance of the effects of the variable are also confirmed in the rest of the models (Model 3-5), which provides a support for the Hypothesis 1.

Model 3 reports the moderating effect of the variable *Overseas R&D Center External Embeddedness*. The interaction term between *Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary* and *Overseas R&D Center External Embeddedness* has positive and significant ($p<0.1$) effect on the dependent variable. The positive and significant effect of the moderator variable *Overseas R&D Center External Embeddedness* can be confirmed in Model 5. These provide a support for Hypotheses 2 that proposes the positive moderating effect of the external embeddedness of overseas R&D subsidiary on the relationship between the extent of headquarter cross-border knowledge sourcing from host country and the subsequent innovative performance of the headquarter. The moderating effect of the variable *MNC Headquarters Knowledge Digestibility* is examined in Model 4. The interaction term of *MNC Headquarters Knowledge Digestibility* and *Cross-border Knowledge Sourcing Via an Overseas R&D Subsidiary* has a non-significant effect on the dependent variable *MNC Headquarters Innovative Performance*. The effect of the moderator variable is non-significant also in the Model 5. In other words, Hypothesis 3 is not supported.

Chapter 6. Discussion and Conclusion

Present study investigates how overseas R&D subsidiaries allow MNC headquarters to source the local knowledge of the host country and to generate subsequent innovation activities. Furthermore, the level of external embeddedness of a foreign R&D subsidiary

and knowledge digestibility that each headquarters retains were suggested as conditions that enhance the effects of a R&D subsidiary on the knowledge sourcing and learning processes of the headquarters. With a dataset of 100 multinationals and the overseas R&D subsidiary geographical distribution for each firm, the hypotheses are examined using the ordinary least squares regression method. It can be confirmed from the results that the cross-border knowledge sourcing and learning activities of MNC headquarters are efficient if the processes are facilitated by the host country R&D subsidiary. In addition, enhanced efficiency in foreign knowledge acquisition and innovation activities by the headquarters are further improved if the MNC overseas R&D center has a good degree of external embeddedness in host country network which can be derived from to previous alliance experiences. However, there was no evidence of any effect of knowledge digestibility by the headquarters on the facilitating role of the host country R&D center when the headquarters attempts to acquire cross-border knowledge and learn from it. One possible explanation of this result can be understood in the case when home country parent firm's knowledge base is already sufficient for R&D activities and external R&D knowledge sourcing. The fact that MNC headquarters have already built s substantial knowledge base on the one hand indicates that the headquarters has the capability for paying attention to their allocation of acquired overseas knowledge (Kang et al., 2015; Koput, 1997). On the other hand, the degree of the contribution made by an overseas R&D subsidiary to the efficient cross-border sourcing activities of the headquarters would be reduced when headquarters is already highly capable in this regard.

6.1 Implication

This study investigates research streams that view MNCs and their R&D offshoring from the perspective of the home-base augmenting mandate empirically. The study emphasizes the roles of the overseas R&D subsidiary in the area of efficiency enhancements of the cross-border knowledge sourcing, learning and subsequent innovative activities of the MNC headquarters. To be specific, this study also examines the characteristics of MNC headquarters and overseas R&D subsidiaries that allow the overseas knowledge sourcing and learning of headquarters to be more efficient.

The present study has several implications for decision makers at MNCs and policymaker. First, the study has managerial implications that would be helpful to decision makers at MNC headquarters who are in charge of R&D offshoring. MNC headquarters R&D should give support to overseas R&D labs for their effective formation of embeddedness in the local communities of the host country so that the headquarters will later enhance its foreign knowledge acquisition and knowledge integration. Second, the results here provide clues to policymakers in the MNC home country. When a multinational enterprise plans for outward FDI for efficient knowledge acquisition and to enhance its innovation activities, it may indicate a decrease in domestic investments in the short run. However, considering that the MNC can improve firm innovation performance via efficient cross-border knowledge sourcing and learning with the aid of an overseas R&D subsidiary, providing institutional or policy support to a domestic MNC will beneficial to the competitiveness of the multinational enterprise and to the competitiveness of the home

country in the long run.

6.2 Limitation and future research

Despite the contributions by and implications of the findings of present study, there exist several limitations. First, one of the assumptions made in this study is that foreign knowledge sourcing by a MNC headquarters occurs through, or at least is aided by, the reverse knowledge transfer mechanism. However, there may remain the possibility that MNC headquarters can directly access foreign knowledge without the aid of a host country R&D subsidiary. Future research can adopt a supplementary measure that serves as a proxy for the extent of reverse knowledge transfers in each of MNC network. One feasible way to do this is to measure the reverse knowledge transfer based on a survey with questionnaires, just as Ambos et al. (2006) operationalized the benefit of reverse knowledge transfer with a survey. Second, because the present study utilized a dataset that includes geographical distributions of MNC R&D subsidiaries in 21 leading R&D countries, there may be a "center of excellence" in a country that is not on the list of 21 countries (Kurokawa, Iwata, & Roberts, 2007).

Due to the lack of up-to-date patent data, and given the fact that the data constituting the R&D subsidiary geographical distribution stems from the observation made in 2008, the focal patent data is limited to patents granted to each MNC in 2011 in the present study. However, there is the possibility that firm innovative activities which occurred during the period of 2009-2010 may not be captured because the patent was granted after 2011.

Regarding the operationalization of independent variable 2, *Overseas R&D Center External Embeddedness*, there are various ways to measure the embeddedness of an overseas R&D subsidiary in a host country. For instance, co-patenting experiences can be an alternative proxy for this. However, in the present study, the industries of focal firms are not confined to knowledge-intensive sectors, which indicates that there are firms in the sector where co-patenting cases are to be found. Nonetheless, measuring embeddedness via the number of alliances can introduce certain limitations. In addition, the alliance counts were collected at the MNC level and not at the subsidiary level because much of the data on such firm alliances does not provide detailed distinctions about whether a specific overseas R&D subsidiary entered into an alliance or not.

When measuring independent variable 3, *MNC Headquarters Knowledge Digestibility*, the ratio of the number of knowledge seeker and knowledge source units is adopted in the present study due to a lack of information about the employees at each R&D subsidiary. Although this operationalization is based on the logic that the center ratio can reflect the complexities of inter-organizational knowledge transfers and the capability to assimilate and understand the transferred knowledge by the target unit, there remains a limitation in this area as well.

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Abstract (Korean)

다국적 기업의 해외 연구개발 지사는 본사에 암묵지적이고 사회적 맥락에 대한 이해에 기반한 지식을 제공함으로써 본사의 효율적인 현지국 지식 습득과 학습에 기여한다. 본 연구는 어떻게 해외 연구개발 지사가 본사로 하여금 해당국의 지역적인 지식을 효율적으로 소싱하고 그로부터 학습하게 도와주는지를 밝히고자 한다. 연구는 또한 현지국의 기업들과 제휴를 맺음으로써 형성되는 해외 연구개발지사의 외부적 배태성이 이후에 본사의 해외 지식 습득과 활용에 미치는 영향에 미치는 효과를 규명한다. 뿐만 아니라, 다국적 기업 본사가 해외 연구개발지사에 비하여 지식 소화성을 갖추고 있는 것이 본사의 해당국 지식 습득과 학습을 용이하게 하는 해외 연구개발 지사의 역할을 더욱 증폭시켜주는 조건임을 제시한다.

본 연구는 2008년 Fortune 500 기업 리스트에 속하는 100개의 다국적 기업들의 해외 연구개발 지사의 지리적 분포에 관한 데이터와 각각의 다국적 기업의 특허 데이터에 기반하여 정립한 가설을 검증하였다. 결과를 통해 다국적 기업의 본사가 해외 연구개발 지사가 지식이 풍부한 해당국에 존재함으로써 이후의 해당국 지식 습득과 학습에 관련한 일련의 활동에 있어 혜택을 볼 수 있음을 확인하였다. 또한, 결과는 해외 연구개발 지사의 해당국 지역 네트워크에서 배태성을 형성하는 것이 이후 본사가 해당국 지식을 소싱 하고자 할 때 해당국가의 연구개발지사가 기여하게 되는 바를 더욱 증폭시킴을 확인하였

다.

주요어 : 다국적 기업, 해외 지식 소싱, 해외 연구개발 지사, 혁신 성과, 사회적 배태성, 지식 소화성
학 번 : 2015-22879